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Can Achilles tendon be affected in patients with intermittent claudication?

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Abstract:

Objective: To investigate ultrasonographically the frequency of Achilles tendon (AT) involvement in patients with intermittent claudication due to lower extremity arterial ischemia.

Materials and Methods: 70 lower extremity in 40 patients with unilateral (n=10) and bilateral (n=30) symptoms of intermittent claudication were studied. 60 age and sex matched asymptomatic lower extremities in 34 subjects served as a control group. Arterial Doppler ultrasonography was done to establish the diagnosis of occlusive arterial disease and the degree of obstruction was recorded. Tendinopathic changes of AT were assessed by ultrasonography (US).

Results: Tendon thickness was increased in patient group (7.35±2.91mm) compared to control group (5.39 ±1.21 mm). Tendinopathic changes like increased thickness, decreased echogenicity and loss of edge sharpness with intraperitenon fluid collection were seen in 54/70 heels in patient group. Among, tendinopathic changes increased thickness and hypoechogenicity has shown a significant correlation with stenotic changes of popliteal (P=0.027), tibialis posterior (P=0.27) and dorsalis pedis arteries (P=0,006), whereas no correlation was found with those of common and superficial femoral arteries.

Conclusion: Tendiopathic changes can be seen in AT in occlusive distal arterial diseases of lower extremity. Ultrasonography may offer a good diagnostic modality in displaying these changes in patients with lower limb ischaemia.

Keywords: Achilles tendon, Ultrasonography, Limb Ischemia.

Introduction:

Intermittent claudication due to peripheral occlusive arterial disease is one of the common problems that affect the limb mobility and quality of life. The symptoms are usually characterized by leg pain on walking. The Achilles tendon (AT) is one of the thickest and strongest tendons in the body which is formed from the tendinous contributions of the gastrocnemius and soleus muscles coalescing approximately 15 cm proximal to its insertion. Along its course in the posterior aspect of the leg, the tendon spirals 30-150° until it inserts into the calcaneal tuberosity on an area without a periosteal layer [1]. The gliding ability of the AT is aided by a thin sheath of paratenon rather than a true synovial sheath. The tendon derives its blood supply from three sources: the musculotendinous junction, the surrounding

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connective tissue through the paratenon and the bone-tendon junction at the insertion site [2]. Although the posterior tibial artery provides the majority of the blood supply, the angiographic and histologic studies have shown that the Achilles tendon has a poor blood supply throughout its length, as determined by the small number of the blood vessels per cross-sectional area [3]. Lagergren et al reported that the area of tendon typically prone to rupture is relatively avascular compared with the rest of the tendon [4]. The AT has been shown to thicken in response to increased activity however, the morphologic changes such as decreased cell density, decreased collagen fibril density, and loss of fiber waviness that occur with aging predispose the tendon to injury [5].

To date ultrasonography (US) has not been applied to examine AT in ischemic lower limbs. For this we aimed to perform ultrasonography to detect the frequency of involvement of AT in patients with intermittent claudication due to lower extremity occlusive arterial disease.

Materials and Methods:

Subjects: Radiological evaluation of the changes in the heels of the study and the control group was fulfilled from October 2015 to January 2016 at an University Hospital. Seventy lower extremity in 40 patients with unilateral (n=10) and bilateral (n=30) symptoms of intermittent claudication were prospectively enrolled in this study. The study group included of 6 female and 34 male lower extremity, with a mean age of 58.4 ± 11.83 years, and a height of 168.31 ± 5.75 cm. On the other hand, 60 lower extremities of 34 asymptomatic volunteers including 7 female and 27 male lower extremities with mean age of 58.50 ± 8.59 years and the height of 164.43 ± 8.96 cm were recruited to the study as a control group. Volunteers with a history of diabetes, Achilles tendon problems, systemic inflammatory disorders, long-term heavy loading of the tendon, or a condition that might influence our results, such as rheumatoid arthritis, spondyloarthropathies, or hypercholesterolemia, were excluded. The study was approved by University Ethics Committee, and all volunteers provided written informed consent.

Radiological examination: US examination was performed by an experienced musculoskeletal radiologist using a commercially available scanner (Siemens Acuson S 3000™ ultrasound system (Siemens Medical Solutions, Mountain View, CA, USA). with (9L4) MHz linear transducer. To examine AT the patients asked to lay prone with their feet hanging free over the end of the examination couch in a neutral position. A care to keep the perpendicular beam to the tendon was maintained at all times to avoid anisotropy. Measurement of antero-posterior diameter of Achilles tendon was taken at the site of the insertion at the postero-superior calcaneal surface (Figure1). Tendinopathic changes such as increased thickness, decreased echogenicity and blurred margins with intraperitenon fluid collection were assessed by ultrasound and recorded. The combination of gray scale imaging with Doppler sonography was used in assessing occlusive arterial disease. Color flow imaging makes it possible to evaluate the full length of the arterial segments of the lower limb and identify the absence of flow signals, sites of increased velocity, flow pattern, evaluate the cross sectional examination of the artery and estimate relative stenosis. On the other hand pulsed Doppler sonography was used to obtain the peak systolic velocity with a Doppler gate placed at sites of aliasing and then 2-4 cm proximal to the suspected lesion and then the velocity ratio is calculated. So that by both color imaging and duplex ultrasonography the diagnosis and the percentage of the occlusion at common femoral, superficial femoral, popliteal, tibialis posterior and dorsalis pedis arteries were recorded. Both of the AT evaluation, US for tendinopathic changes and Doppler US for assessment of the occluded

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arteries were performed by the same radiologist.

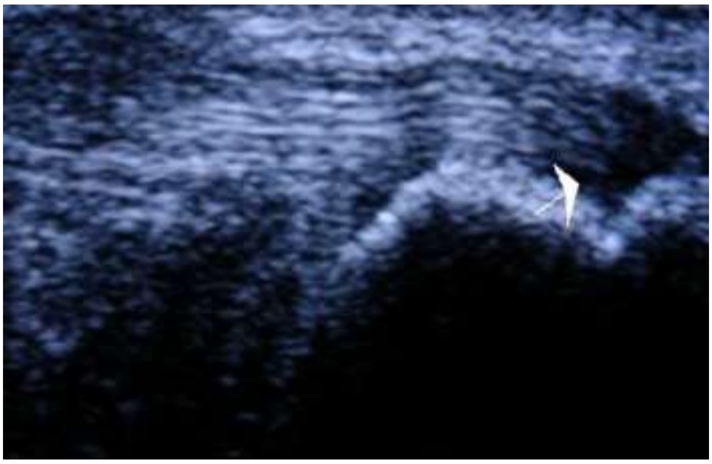
Figure-1: Ultrasonographic image of Achilles tendon in prone position (P: probe, AT: Achilles tendon, C: calcaneus)

Statistical analysis: Mean values, standard deviation (SD) and ranges of age, height, US measurement of Achilles tendon thickness were calculated. The chi square test was used to study the relation between the degree of arterial occlusion and the tendinopathic findings like decreased echogenicity, loss of edge sharpness, and fluid in the paratenon and retrocalcaneal bursitis. Mann Whitney U test was used to compare the degree of obstruction with the tendon thickness. Spearman correlation test was used to study the correlation between the AT thickness, age and height.

Results: Tendinopathic changes like increased thickness, decreased echogenicity, loss of edge sharpness, intraperitenon fluid collection and bursitis were seen in 54/70 (77.1%) heels in patients with intermittent claudication.

The AT was thicker (7.35 ± 2.91 mm) in the study population compared to the control group (5.39 ± 1.21 mm). The echogenicity of the tendon was reduced in 54/70 (77.1%) lower limb in the study group (Figure 2).

Figure-2 : Hypoechogenic area in Achilles tendon (Arrow head)



The other findings in the study group, were loss of edge sharpness seen in 42/70 (60%), intraperitenon fluid seen in 26/70 (37%) and retrocalcaneal bursitis seen in 26/70 (37%) lower extremity. All the tendinopathic changes were seen in only 4/60 (6.7%) lower limb of the control group (Table I).

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Table I: The tendinopathic findings of ultrasound in both study and control group.

(n)	Achilles tendon thickness (mm)	Decreased Echogenicity (n %)	Loss of Edge Sharpness (n %)	Peritendinous Fluid (n %)	Retrocalcaneal Bursitis (n %)
Study group (35)	7.35±2.91	27 (77.1%)	21 (60%)	13 (37.1)	13 (37.1%)
Control group (30)	5.39±1.21	2 (6.7%)	2 (6.7%)	2 (6.7%)	2 (6.7%)

Table II shows the results of the Doppler US expressed as the affected artery, number and percentage of the occlusion at the lower limb arteries.

Table II: Data of Doppler Ultrasound of ultrasound results of expressed as the percentage of obstruction in the arteries of the lower limb in 40 patients

Percentage of obstruction %	FA (n)	SF (n)	POP (n)	TP (n)	DP (n)
100%	4(11.4%)	13(37.1%)	7(20%)	8(22.9%)	9(25.7%)
90%	4(11.4%)	1(2.9%)	-	1(2.9%)	-
80%	2(5.7%)	2(5.7%)	1(2.9%)	-	-
70%	1(2.9%)	1(2.9%)	2(5.7%)	-	-
60%	-	1(2.9%)	-	-	-
50%	5(14.3%)	2(5.7%)	6(17.1%)	1(2.9%)	1(2.9%)
40%	1(2.9%)	1(2.9%)	-	-	-
30%	2(5.7%)	2(5.7%)	-	-	-
20%	-	1(2.9%)	2(5.7%)	-	-
10%	-	-	-	-	1(2.9%)
No obstruction	16(45.7%)	11(31.4%)	17(48.6%)	25(71.4%)	24(68.6%)
Total	35	35	35	35	35

FA: Femoral artery, **POP**: Popliteal artery, **SF:** Superficial femoral artery, **TP:** Tibialis posterior artery,

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DP: Dorsalis pedis artery

A significant p value between the decreased echogenicity of the Achilles tendon and the stenotic changes of the tibialis posterior (p=0.027) and dorsalis pedis (p=0.006) arteries were detected. The same strong p value between the measured thickness of AT, popliteal (p=0.027) and tibialis posterior (p=0.021) arteries were also determined. However, The differences between averages of the Achilles tendon thickness, age and height was not significant.

The other tendinopathic changes like loss of edge sharpness, intraperitenon fluid and retrocalcaneal bursitis have not shown any important statistical value with stenotic changes of the lower extremity arteries (Table III).

Table III: The overall statistical approach between the tendinopathic changes of Achilles tendon and stenothic changes of the lower limb arteries

	Achilles tendon thickness	**Decreased Echogenicity**	**Loss of Edge Sharpness**	**Peritendinous Fluid**	**Retrocalcaneal Bursitis**
FA	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**
SF	**n.s.**	**n.s.**	**n.s.**	**n.s.**	**n.s.**
POP	**P=0.027**	**n.s.**	**n.s.**	**n.s.**	**n.s.**
TP	**P=0.021**	**P=0.027**	**n.s.**	**n.s.**	**n.s.**
DP	**n.s.**	**P=0.006**	**n.s.**	**n.s.**	**n.s.**

FA: Femoral artery, **POP:** Popliteal artery, **SF:** Superficial femoral artery, **TP:** Tibialis posterior artery, **DP:** Dorsalis pedis artery, **n.s. :** not significant.

Discussion:

Normal AT is echogenic and exhibits a characteristic fibrillar structure on longitudinal scan. The tendon is surrounded by a paratenon which is a dense connective tissue structure appears as echogenic borders surrounding the tendon [6,7]. AT is a relatively large superficial structure, easily visualized by US which can be helpfull in distinguishing between Achilles tendinitis, paratenonitis, and retrocalcaneal bursitis. Many previous studies reported the enthesopathic changes of the AT and the use of US in evaluating these changes [8,9]. AT does not have a true synovial sheath but instead has a paratenon. The paratenon is a connective tissue sheath that surrounds the entire tendon and is able to stretch 2 to 3 cm with movement, which allows maximal gliding action. Running produces forces up to eight times the body's weight, placing significant repetitive stress on the tendon for

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prolonged periods [10]. Tendonitis in athletes is usually caused by training errors or wearing improperly fitting shoes. Abnormal biomechanics and friction from extrinsic or external pressure may result in the same scenario.

To our knowledge, there has been no ascribed association of limb ischemia with Achilles tendinopathic changes demonstrated with US. So far, only one patient has been reported with spontaneous bilateral rupture of AT secondary to lower limb ischemia in the literature [11].

We have studied the tendinopathic changes of AT by US in patients complaining of intermittent claudication due to limb ischemia. Ultrasonographically, the homogeneous thickness, uniform fibrillar echotexture, and sharply defined echogenic margins of the tendon are considered as the main features of normal appearance of the tendon [8]. Loss of the fibrillar echotexture is always an abnormal finding and it can range from a diffuse blurring of the tendon texture to focal aspects of fibrillar interruptions.

In our study, US examination demonstrated a significant thickening of AT in comparison with the control group (Table I). Maffulli reported, that a diffuse thickening of the tendon is a common condition in persons older than 35 years [12]. Aging, vascular compromise, or a combination of these factors may result in increased predisposition to injury and microtears within the tendon. The other common finding shown in the patient group was the decrease in the echogenicity of the tendon that was seen in 54 of 70 (77.1%) heels of the patient group. Doppler findings of occluded popliteal artery significantly correlated with the increased thickness whereas dorsalis pedis artery findings correlated with the decreased echogenicity of AT. Although popliteal and dorsalis pedis arteries with ischemic changes revealed a significant relation with the tendinopathic changes of AT, thickening and decreased echogenicity were specifically seen in cases of affected TP artery respectively. This could be due to the fact that TP artery provides the majority of the blood supply which is also found to vary with age, being more abundant in younger individuals [3].

We believe that Achilles tendinopathy occurred due to somewhat old age of the study group (mean age 58.4 ± 11.83 years) and the ischemic arterial changes in the lower limb region appeared especially when it affects TP artery. As TP artery provides the majority of the blood supply of AT so that the ischemic changes affecting the arteries in the peritendinous tissues may lead to hypoxic degenerative changes in AT [13]. Factors, such as vascular compromise and aging increase predisposition to microtrauma and result in inadequate repair of the tendon matrix, impairment of matrix production and ultimately results in collagen degeneration, fibrosis, and calcification within the tendon [5,14,15]. On the other hand it has been noticed that although the number and the degree of the occlusion were prominently detected at the proksimal parts such as femoral and superficial arteries, Achilles tendinopathy were visualized more with distal artery occlusion of the lower limb. This fact is due to the blood supply of the tendon provided by distal longitudinal arteries that run the length of the muscle complex [4,16]. Moreover, the blood supply diminishes with age, predisposing this area of the tendon to chronic inflammation and possible rupture.

Symptoms of Achilles tendinopathy usually develops gradually including tenderness, mild or severe pain and swelling. The pain may come on gradually or may only occur when walking or running. Patients complaining of intermittent claudication can not be aware of their early tendinopathic symptoms and late diagnosis of tendinopathy may lead to chronic tendonitis or even rupture. For this, US examination of AT in patients complaining of intermittent claudication can be of benefit in diagnosing early changes of tendinopathy [17] and preventing further conditions that can severely limit mobility and quality of life. One limitation of our study was

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that control and study groups do not represent the all age and activity populations, also normal magnetic resonance imaging of AT could be compared with ultrasound in control and study groups. Also more studies with larger number of patients and different age groups can be designed.

In conclusion, occlusive arterial diseases of the lower limb may weaken the AT enough to cause tendinopathy and even rupture with minor trauma. Delayed diagnosis of AT in ischemic lower limb, with persistent difficulty in mobilization due to intermittent cluadication, remains a challenge in determining the proper management. However, the quick quality improvement of ultrasonographic equipment and development of high frequency ultrasound probes can lead to a wide spread clinical use of US and early detection of tendon problems.

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